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INT CL[6] F16D 3/16 3/20 3/22 3/221 3/223 3/224 3/226 3/227 3/84
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(54) Propeller shaft

(57) A propeller shaft comprises two constant velocity ratio plunging universal joints 1, (2, Figure 1) which each have an outer joint part 11 with first ball tracks 17 and an inner joint part 13 with intersecting second ball tracks 18, torque transmitting balls 16 in a cage 14 coupling the outer and inner joint parts. Each inner joint part 13 is non-removably connected to shaft element 3 and is coaxially insertable into cage 14. The cage opening facing the shaft element 3 may have a smallest inner diameter D_K greater than the greatest outer diameter D_N of the inner joint part 13, the outer joint part 11 carrying at its open end facing the shaft element 3 a stop element 19 for the cage. Alternatively (Figure 6), the cage opening facing the shaft element (33) may have a smallest inner diameter smaller than the greatest outer diameter of the inner joint part (43), the cage opening then forming an axial stop for the inner joint part (43), the inner joint part and the cage being assembled and disassembled by a bayonet action.

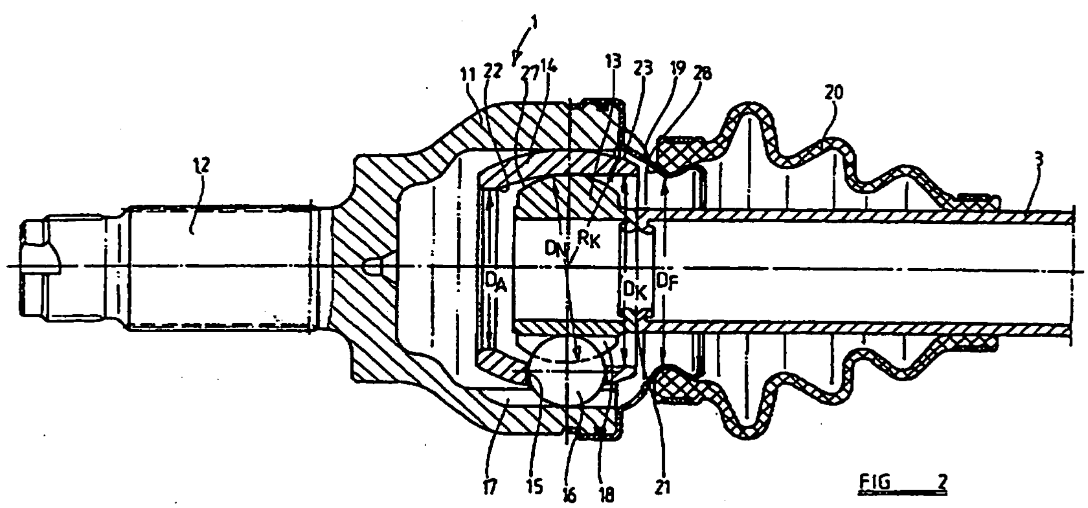

FIG 2

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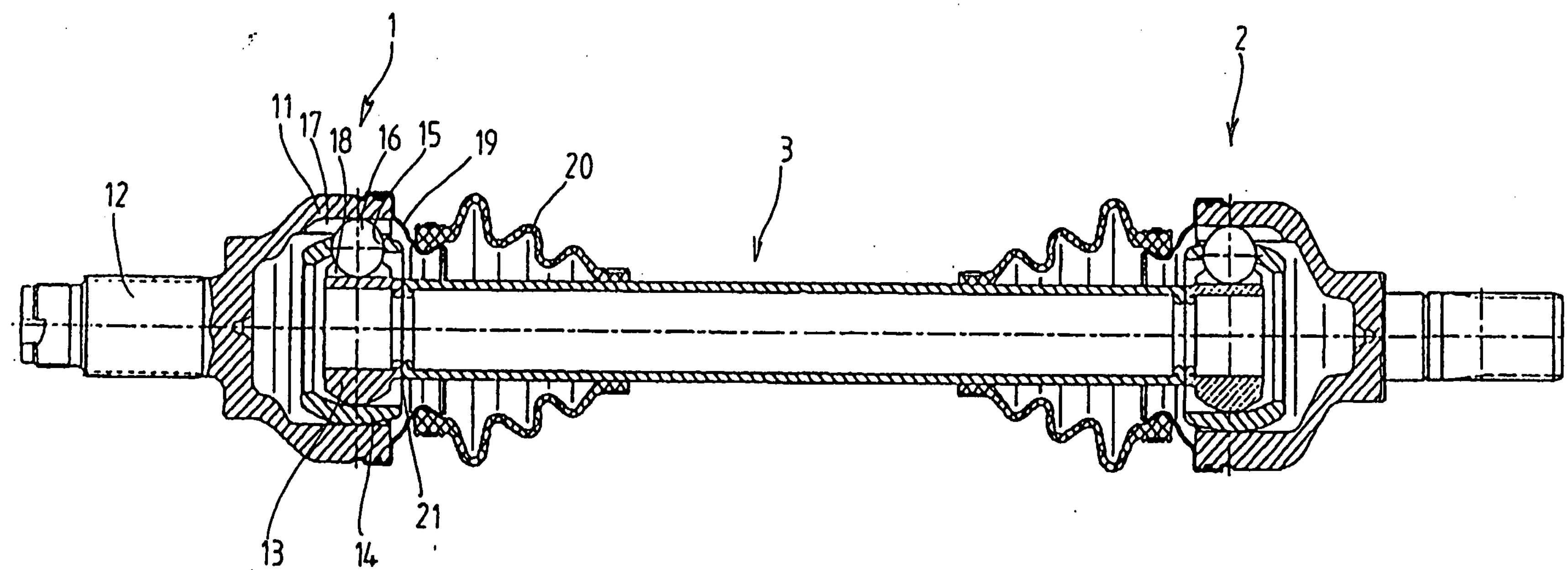

FIG 1

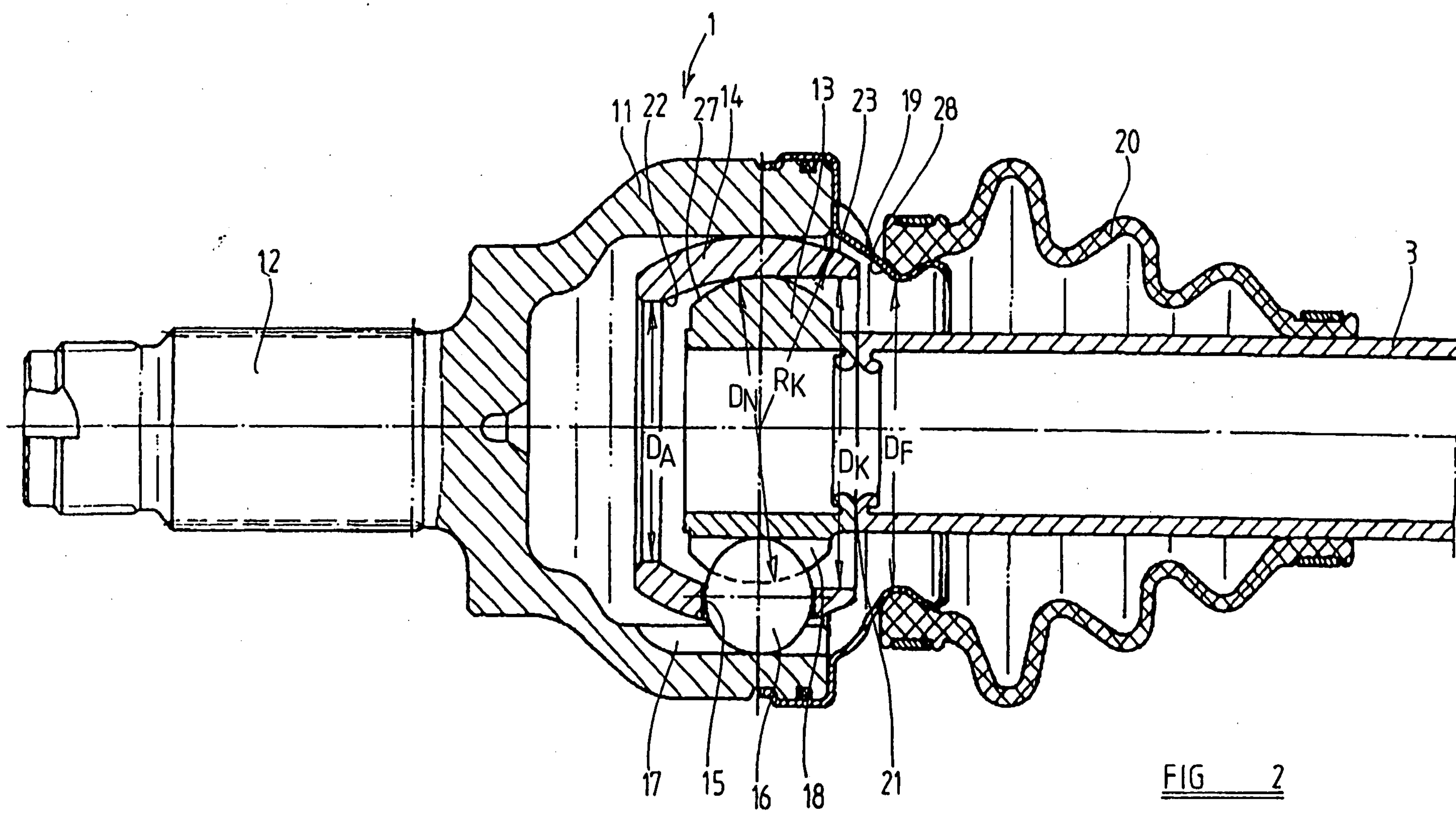

FIG 2

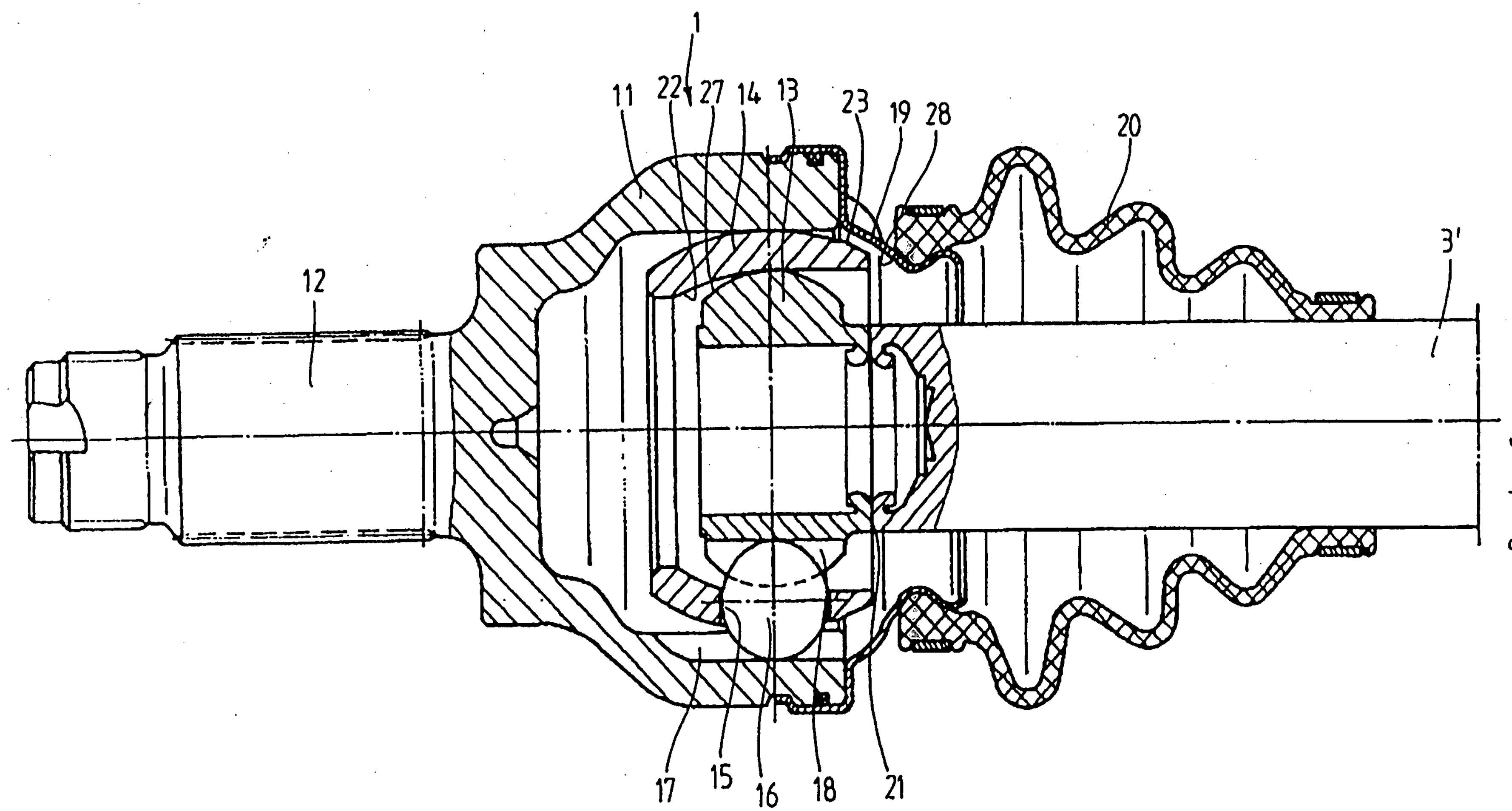

FIG 3

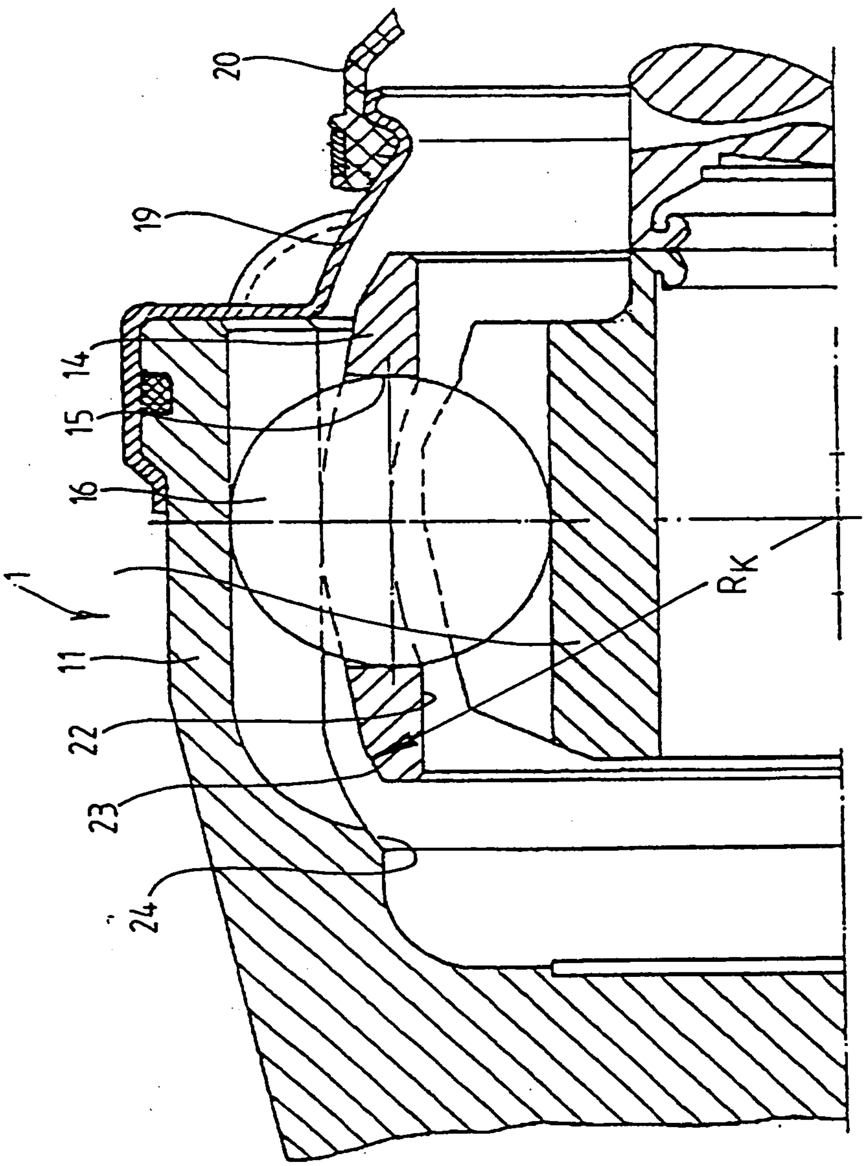

FIG 4

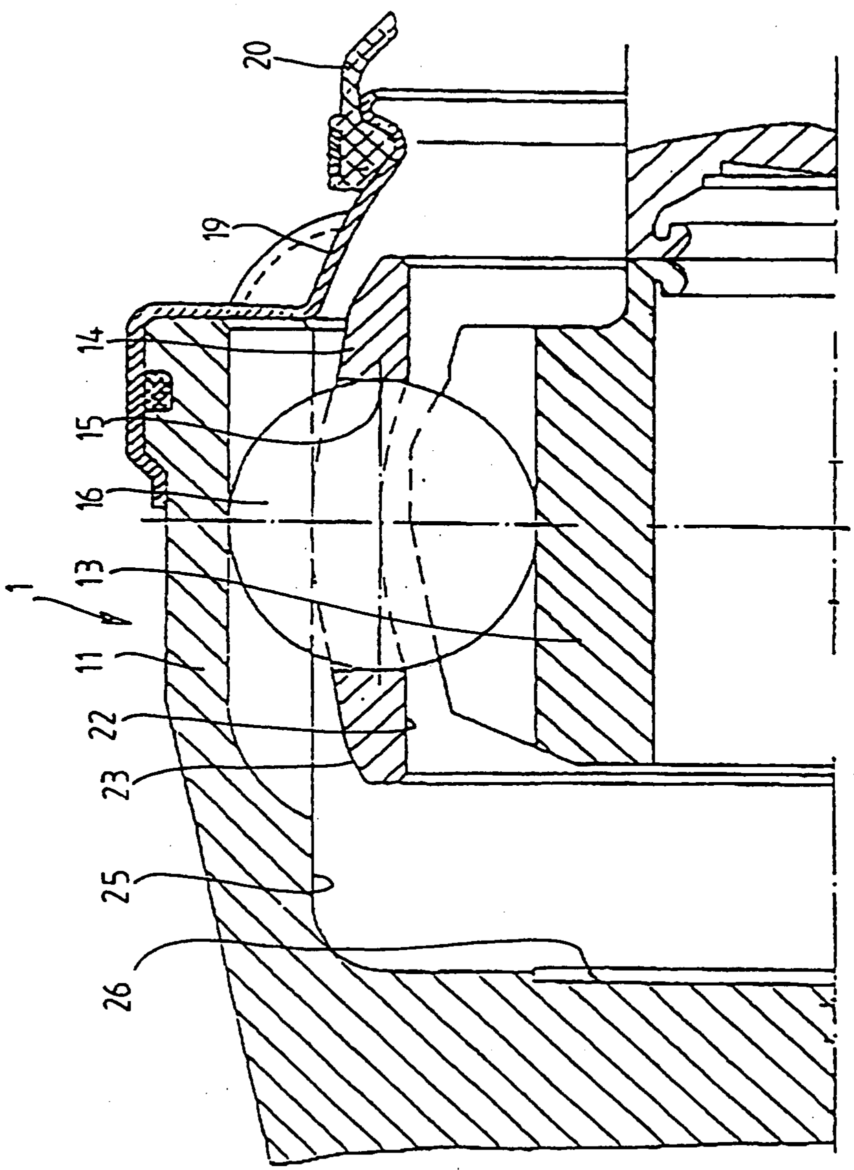

FIG 5

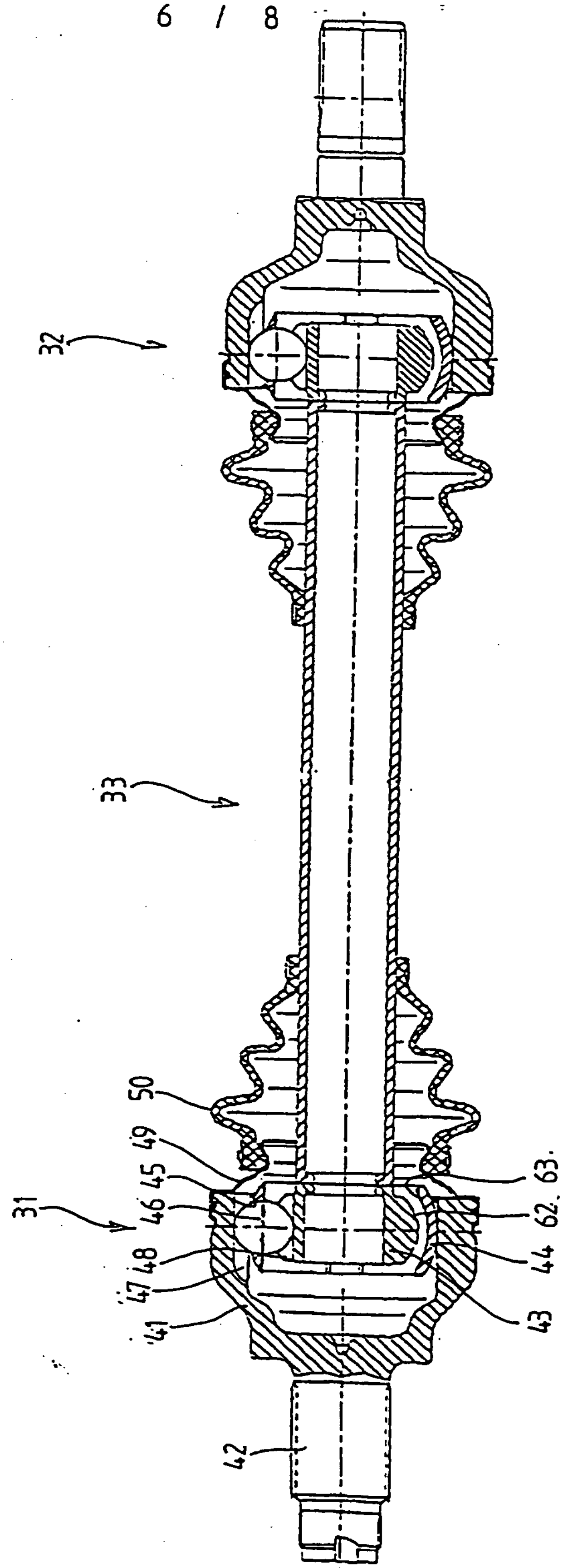

FIG 6

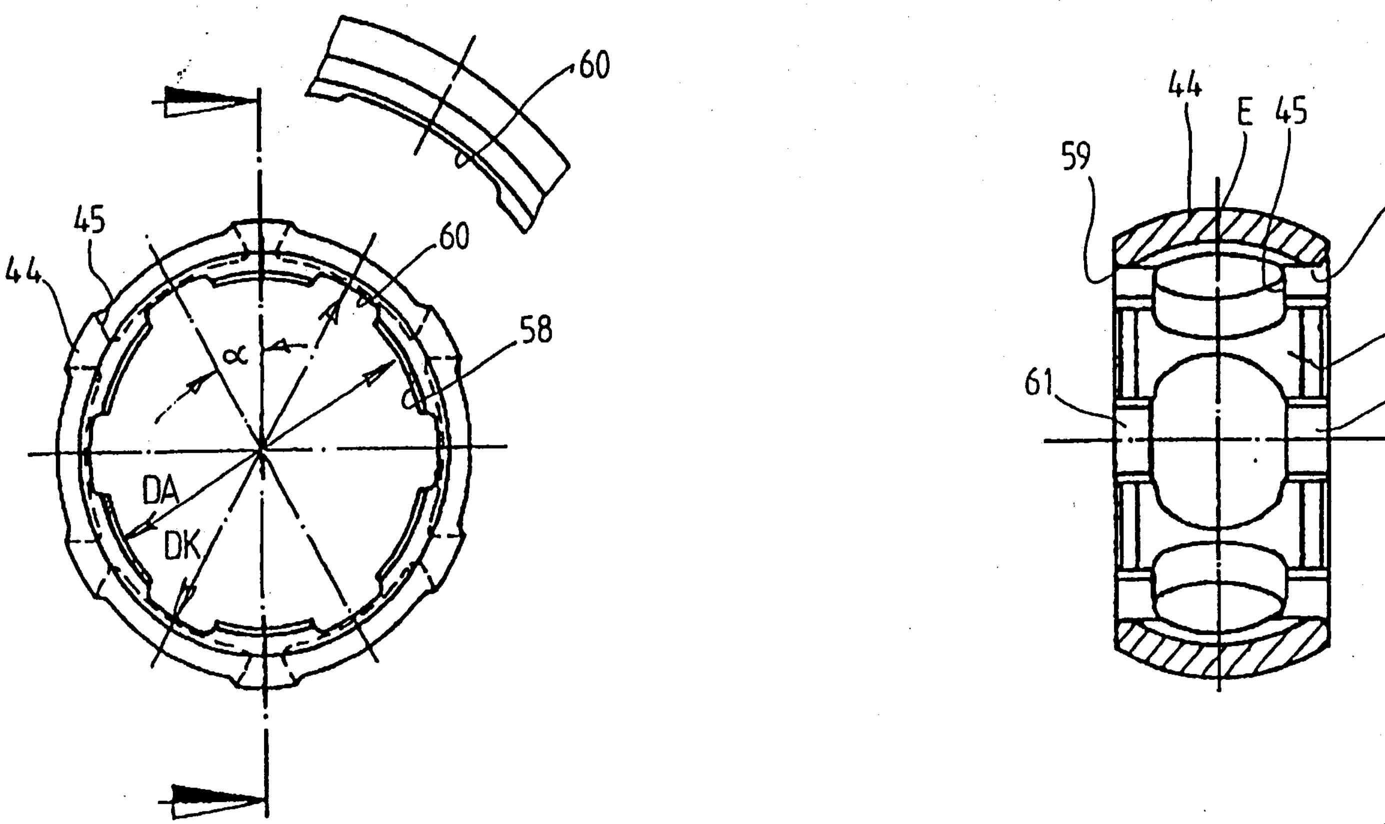

FIG 7

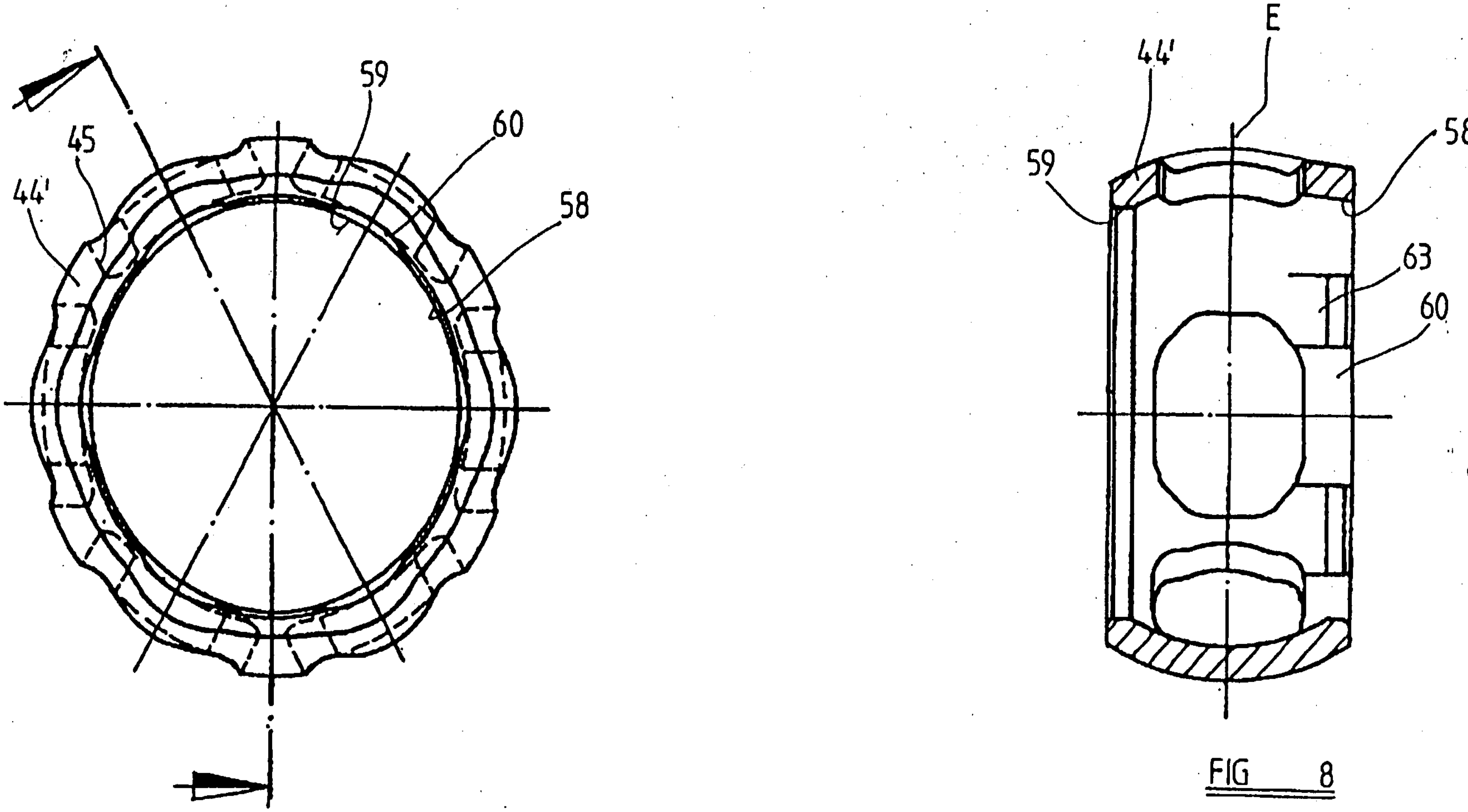

FIG 8

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Title: PROPELLER SHAFT

Description of Invention

The invention relates to a propeller shaft comprising two constant velocity ratio universal joints which each comprise an outer joint part having first ball tracks and being connectable to driving means, an inner joint part having second ball tracks and being attached to a shaft element connecting the inner joint parts, torque transmitting balls guided in corresponding opposed first ball tracks in the outer joint part and second ball tracks in the inner joint part, and an annular cage which is provided with circumferentially distributed windows, which receives the balls in the windows and holds the balls in one plane, the two constant velocity universal joints being plunging joints in which corresponding first ball tracks and second ball tracks cross one another in developed view of the joint, being inclined in opposite senses relative to the longitudinal axis of the joint. Such plunging joints of the crossed-track type are commonly, and will herein be, referred to as VL plunging joints.

A shaft of said type is known from DE 37 10 572 C2, and a shaft of a similar type with a fixed (non-plunging) joint is described in DE 34 30 067 C1. VL joints of the type discussed here, which can be mounted entirely axially, but are secured against automatic removal are known from DE 38 20 449 A1, wherein the inner joint part of the VL plunging joint is removably connected by splines to a separately produced shaft element. On the other hand, it is already known from said DE 34 30 067 C1 to connect the inner joint part of a VL plunging joint to a hollow shaft by welding.

It is the object of the present invention to provide propeller shafts of the type herein first set fourth which are optimised further in respect of assembly and production cost.

According to a first aspect of the invention, the inner joint parts are each non-removably connected to the shaft element; the outer joint parts, at their opening ends facing the shaft element, are each provided with a placed-on annular stop element which forms an axial stop for the respective cage; and each inner joint part, together with the attached shaft element is coaxially insertable into the respective cage, the cage opening facing the shaft element comprising a smallest inner diameter which is greater than the greatest diameter of the respective inner joint part.

As a result of the combination of characteristics in accordance with this first aspect of the invention, all propeller shaft parts, including the VL joints, can be mounted coaxially, i.e. in coaxial alignment in respect of one another. In consequence, the sequences of movement and handling during assembly become simpler and easier to execute. At the same time, as there is no longer any need for angular movements between the inner joint part and the outer joint part for fitting the balls, the inner joint part can either be produced to be integral with the shaft element or it can be non-removably connected to the shaft element. Unintentional dismantling of the VL joints is prevented by the annular stop elements fitted after axial mounting of the outer joint part, cage and inner joint part has been completed. If the opening diameter of the stop element in a preferred embodiment is greater than the outer diameter of the inner joint part, it is possible to produce the shaft element and inner joint part in one piece. If the opening diameter of the stop element is smaller than the outer diameter of the inner joint part, the annular stop elements first have to be slid on to the shaft element and subsequently, the shaft element has to be non-disconnectably joined to the inner joint parts. Preference is given to a friction

welding process which can be carried out on a tubular shaft element without the need for any special preparatory work.

The stop means for the cage, preferably provided in the form of plate metal caps to prevent axial extraction, are preferably designed to be spherical, so that angular movements can occur in the point of contact without the position of the joint centre being adversely affected.

In accordance with a second aspect of the invention, the opening of the cage, which opening faces the shaft element, comprises a smallest inner diameter which is smaller that the greatest outer diameter of the respective inner joint part and which forms an axial stop for the respective inner joint part; and each inner joint part connected to the shaft element is coaxially introducible into the respective cage by virtue of the cage opening facing the shaft element being enlarged by recesses which comprise a greater radial dimension and a greater circumferential extension than longitudinal webs of the respective inner joint part defined between each two adjacent ball tracks thereof.

In this case, too, due to the combination of characteristics in accordance with the invention, all propeller shaft parts, including the VL joints, can be assembled coaxially, i.e. in coaxial alignment in respect of one another. The assembly of the inner joint parts with the cages takes place in accordance with the sequence of movements of a "bayonet" connection, i.e. the axial introduction of the parts is followed by a rotational movement which causes the tracks in the inner joint part to overlap with the windows in the cage, thus enabling the balls, subsequently, to be inserted from the outside of the cage through the windows into the ball tracks.

Firstly, the longitudinal webs of the inner joint part are aligned relative to the recesses in the cage opening with reference to their relative angular positions, so that the inner joint part can be inserted into the cage. This type of axial assembly, too, allows the shaft element and the inner joint parts to be

produced in one piece or the shaft element and the inner joint parts to be non-disconnectably joined prior to the assembly of the joint.

In this embodiment, the shape of the cage provides the stop means against unintentional axial dismantling of the joint in that the inner joint part, on the inside, stops against the cage wall parts at the opening end. This cage embodiment does not require the plate metal cap according to the first proposed solution, so that, in this case, a convoluted boot for sealing the joint can be secured directly on the outer joint part; if a plate metal cap is provided for receiving the convoluted boot, such a cap does not have any stop functions.

In a first embodiment, the cage may be designed in such a way that the recesses constitute notches in the cage wall part at the shaft element end thereof. Such recesses can easily be produced by machining operations, especially by broaching.

According to a second cage embodiment it is proposed that the recesses may be formed by corrugations in the cage wall part at the shaft element end, with the wall thickness of the wall part remaining unchanged. These can be produced by radial deformation operations carried out on a cage which, originally, is produced to be rotationally symmetrical, especially by expanding the cage which, initially, is produced with a circular inner opening at the shaft end.

For designing the stops used for limiting the axial introduction of the inner joint part into the outer joint part, there are available several alternatives which are described in the subclaims and which refer to the position of the stop faces in the outer joint part. Said stop faces are preferably part-spherical in shape, so that the stop is able to support angular movements without the position of the joint centre being adversely affected.

In a particularly advantageous embodiment, the shaft element is provided in the form of a tubular member, with the production of the

connection with the inner joint parts being facilitated by using a friction welding process.

According to a further advantageous embodiment it is proposed to produce the shaft element in such a way that it is integral with the inner joint parts. The purpose of this measure is to reduce the number of parts and the number of production stages respectively.

According to a particularly advantageous method of production, the shaft element may be welded to the inner joint parts before it is subjected to a hardening operation together with said inner joint parts. The weld, in particular, can be included in the hardening operation and quenching and tempering operation respectively.

Preferred embodiments of the invention will be explained below with reference to the drawings, wherein:-

Figure 1 shows a shaft of a first type in accordance with the invention, having two VL plunging joints;

Figure 2 shows a VL plunging joint in accordance with the invention, in the form of a detail with a welded-on solid shaft element according to Figure 1, and with an axial stop being provided between the inner joint part and the cage;

Figure 3 shows a VL plunging joint in accordance with the invention, in the form of a detail with a welded-on tubular shaft element according to Figure 1, and with an axial stop being provided between the inner joint part and the cage;

Figure 4 shows a VL plunging joint in accordance with the invention, in the form of a detail with an axial stop being provided between the cage and the outer joint part;

Figure 5 shows a VL plunging joint in accordance with the invention, with an axial stop between the inner joint part and the outer joint part;

Figure 6 shows a shaft of a second type in accordance with the invention, with two VL plunging joints;

Figure 7 shows the cage of the VL joint according to Figure 6

a) in an axial view,

b) in a longitudinal section;

Figure 8 shows the cage of a modified VL joint

a) in an axial view,

b) in a longitudinal section.

Figure 1 shows a propeller shaft consisting of two identical plunging joints 1, 2 and of a shaft element 3. As shown at joint 1, the joints each comprise an outer joint part 11 with a formed-on shaft journal 12 adapted to be connected to driving means, an inner joint part 13, a cage 14 and balls 16 held in windows 15 of the cage. The balls 16 are guided in tracks 17 in the outer joint part 11 and tracks 18 in the inner joint part 13, which tracks face one another in corresponding pairs. The tracks in each pair are oppositely inclined to the longitudinal axis of the joint so that in developed view of the joint the tracks cross one another. A plate metal cap 19 one end of which is secured to a convoluted boot 20 is arranged at the outer joint part 11 at the shaft element end. The tubular shaft element 3 to which the convoluted boot 20 is secured by means of its other end is welded to each of the inner joint parts 13. The tubular shaft element 3 and the inner joint part 13 are connected to one another by a friction weld 21. Details regarding the design of the joints will be described further in connection with Figures 2 and 3.

In Figures 2 and 3, the details of a VL constant velocity plunging joint 1 with the shaft element 3 have been given the same reference numbers as in Figure 1. To that extent, reference is made to the description of Figure 1. In Figure 2, the shaft element 3 is again shown in the form of a tube, and in Figure 3 a shaft element 3 is shown in the form of a solid shaft. As indicated by

arrows, the smallest opening diameter D_F of the plate metal cap 19 as well as the opening diameter D_K of the cage 14 at the shaft element end are each greater than the outer diameter D_N of the inner joint part 11. On the other hand, the opening diameter D_A of the cage 14 at the shaft journal end is less than the greatest outer diameter D_N of the inner joint part. In this embodiment, there is provided an inner cage face 22 which forms an axial stop for a part-spherical outer face 27 of the inner joint part 11. The outer face 23 of the cage 14 at the shaft element end has the same radius of curvature R_K as a part-spherical inner face 28 of the plate metal cap 19 with the inner radius of curvature R_F. It is therefore possible for angular movements of the joint to occur at the limits of plunging movement set by the stops, without the centre of articulation being axially displaced.

Figure 4 shows a VL plunging joint in an embodiment which is modified as compared to Figures 2 and 3, with identical details having been given identical reference numbers. Figure 4 deviates from Figures 2 and 3 in that the inner face 22 of the cage 14 is continuously internally cylindrical and thus does not form an axial stop for the inner joint part 13. However, at the outer joint part, at the shaft journal end, there is provided an internally part-spherical stop face 24 for the respective spherical outer face 23 of the cage 14, with the radius of curvature of said stop face 24 being identical to the outer spherical radius R_K of the cage face which co-operates with the stop face 24.

Figure 5 shows a VL plunging joint which is similar to that shown in Figure 4, and wherein, again, the inner face 22 of the cage is entirely cylindrical. This embodiment comprises a larger recess 25 in the outer joint part, which recess 25 prevents the cage 14 from axially stopping against the outer joint part 11 when being axially inserted. However, the outer joint part 11 is provided with a stop face 26 which, during the inserting process, directly stops the inner joint part 13.

Figure 6 shows a propeller shaft comprising two identical plunging joints 31, 32 and a shaft element 33. As shown with reference to joint 31, the joints each comprise an outer joint part 41 with a formed-on shaft journal 42, an inner joint part 43, a cage 44 and balls 46 held in windows 45 of the cage 44. The balls 46 are guided in tracks 47 in the outer joint part 11 and in tracks 48 in the inner joint part 13, which tracks 47, 48 correspond to one another. At the shaft element end of each joint, a plate metal cap 49 holding a convoluted boot 50 at one end is placed on the respective outer joint part 31. In this case, said plate metal caps do not have the function of an axial stop. The inner joint parts 43 are each followed by a hollow shaft element 33 to which, in each case, the respective convoluted boot 50 is secured at its other end. As can be seen in the upper half of the section, the cage 44, on both sides, is provided with circumferential regions through which longitudinal webs 62 positioned between the ball tracks 18 may be guided, when the inner joint part 43 is in a coaxial position. As also shown in the lower half of the section, the longitudinal webs 62, in the assembled position, are each aligned with wall parts of the cage 44, which wall parts prevent axial dismantling towards the shaft element 33 in that they have inner faces 63 which form an axial stop for the inner joint part 43.

Figure 7 shows the cage 44 of the joints of Figure 6 in an enlarged scale, with the cage 44 being designed approximately symmetrically relative to a central plane E. In addition to the window 45 already referred to in Figure 6, Figure 7 shows an opening 58 at the shaft element end and an opening 59 at the cover end, which openings each have a smallest opening diameter D_A which is smaller that the greatest diameter D_N of the inner joint part according to Figure 3. Furthermore, the openings 58, 59 comprises notches 60, 61 which form a greater diameter D_K which is greater than the greatest hub diameter D_N of the inner joint part, with the width of the notches 60, 61 being greater than the width of the longitudinal webs 62 between each two ball tracks 48 in the inner joint part. In this way, the inner joint part can be coaxially assembled with the

cage 44 by means of a bayonet action in that, after axial introduction of the inner joint part, and a rotation thereof by the angle α, the longitudinal webs 62 between the ball tracks 48 are aligned with, and thus axially secured by means of, inner stop faces 63.

Figure 8 shows a cage which has similar characteristics to those shown in Figure 7. However, the cage 44^1 which initially is symmetrical relative to the central plane E, is provided with expanded portions 60 at the inner opening 58 at the shaft end only, whereas the inner opening 59 at the cover end retains its circular shape. As can be seen in the plan view of the inner opening 58, the expanded portions are provided by deforming the circumference of the inner opening 58 in a circumferentially corrugated way, with the wall thickness remaining unchanged. Through the expanded portions 60 it is possible to see the rear inner edge of the second opening 59.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS:

1. A propeller shaft comprising two constant velocity ratio universal joints which each comprise an outer joint part having first ball tracks and being connectable to driving means, an inner joint part having second ball tracks and being attached to a shaft element connecting the inner joint parts of the two joints, torque transmitting balls guided in corresponding first ball tracks in the outer joint part and second ball tracks in the inner joint part, and an annular cage which is provided with circumferentially distributed windows, which receives the balls in the windows and holds the balls in one plane, the two constant velocity ratio universal joints being plunging joints in which corresponding first ball tracks and second ball tracks cross one another in developed view of the joint, being inclined in opposite senses relative to the longitudinal axis of the joint, wherein

the inner joint parts are each non-removably connected to the shaft element;

the outer joint parts each carry an annular stop element which is provided at its respective open end facing the shaft element and which forms an axial stop for the respective cage; and

each inner joint part with the attached shaft element is coaxially insertable into the respective cage, the cage opening facing the shaft element having a smallest inner diameter which is greater than the greatest outer diameter of the respective inner joint part.

2. A propeller shaft according to Claim 1, wherein the outer diameter of the inner joint part is smaller than the smallest opening diameter of the respective annular stop element.

3. A propeller shaft comprising two constant velocity ratio universal joints which each comprise an outer joint part having first ball tracks and being connectable to driving means, an inner joint part having second ball tracks and being attached to a shaft element connecting the inner joint parts of the two joints, torque transmitting balls guided in corresponding first ball tracks in the outer joint part and second ball tracks in the inner joint part, and an annular cage which is provided with circumferentially distributed windows, which received the balls in the windows and holds the balls in one plane, the two constant velocity ratio universal joints being plunging joints in which corresponding first ball tracks and second ball tracks cross one another in developed view of the joint, being inclined in opposite senses relative to the longitudinal axis of the joint, wherein

the inner joint parts are non-removably connected to the shaft element;

the opening of the cage facing the shaft element has a smallest inner diameter which is smaller than the greatest outer diameter of the respective inner joint part and which forms an axial stop for the respective inner joint part; and

each inner joint part connected to the shaft element is coaxially introducible into the respective cage by virtue of the cage opening facing the shaft element being enlarged by recesses which comprise a greater radial dimension and a greater circumferential extension than longitudinal webs of the respective inner joint part defined between each two adjacent ball tracks thereof.

4. A propeller shaft according to Claim 3, wherein the recesses are constituted by notches in the cage wall part at the shaft element end of the cage.

5. A propeller shaft according to Claim 3, wherein the recesses are constituted by corrugations in the cage wall part at the shaft element end of the cage, the wall thickness of the wall part remaining unchanged.

6. A propeller shaft according to Claim 5, wherein the corrugations are formed by alternating spherical and conical portions of the cage wall part at the shaft element end of the cage.

7. A propeller shaft according to any one of Claims 1 to 6, wherein the inner diameter of the opening of the cage, which opening faces away from the shaft element, is smaller than the outer diameter of the inner joint part and forms an axial stop for the inner joint part.

8. A propeller shaft according to any one of Claim 1 to 6, wherein the inner diameter of the opening of the cage, which opening faces away from the shaft element, is greater than the outer diameter of the inner joint part and the outer joint part is provided with a part-spherical axial stop face for the cage.

9. A propeller shaft according to any one of Claims 1 to 6, wherein the inner diameter of the opening of the cage, which faces away from the shaft element is greater than the outer diameter of the inner joint part and the outer joint part is provided with an axial stop face for the inner joint part.

10. A propeller shaft according to any one of Claims 1 to 9, wherein the shaft element is a tubular member.

11. A propeller shaft according to any one of Claims 1 to 10, wherein the shaft element is integral with the inner joint parts.

12. A propeller shaft according to any one of Claims 1 to 10, wherein the shaft element has been welded to the inner joint parts of the plunging joints and has subsequently been subjected to a hardening treatment.

13. A propeller shaft substantially as hereinbefore described with reference to any of the accompanying drawings.

14. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS:

1. A propeller shaft comprising two constant velocity ratio universal joints which each comprise an outer joint part having first ball tracks and being connectable to driving means, an inner joint part having second ball tracks and being attached to a shaft element connecting the inner joint parts of the two joints, torque transmitting balls guided in corresponding first ball tracks in the outer joint part and second ball tracks in the inner joint part, and an annular cage which is provided with circumferentially distributed windows, which receives the balls in the windows and holds the balls in one plane, the two constant velocity ratio universal joints being plunging joints in which corresponding first ball tracks and second ball tracks cross one another in developed view of the joint, being inclined in opposite senses relative to the longitudinal axis of the joint, wherein

the inner joint parts are each non-removably connected to the shaft element;

the outer joint parts, at open ends thereof facing the shaft element, each carry an annular stop element which forms an axial stop for the respective cage; and

each inner joint part together with the attached shaft element is coaxially insertable into the respective cage, the cage opening facing the shaft element having a smallest inner diameter which is greater than the greatest outer diameter of the respective inner joint part.

2. A propeller shaft according to Claim 1, wherein the outer diameter of the inner joint part is smaller than the smallest opening diameter of the respective annular stop element.

3. A propeller shaft comprising two constant velocity ratio universal joints which each comprise an outer joint part having first ball tracks and being connectable to driving means, an inner joint part having second ball tracks and being attached to a shaft element connecting the inner joint parts of the two joints, torque transmitting balls guided in corresponding first ball tracks in the outer joint part and second ball tracks in the inner joint part, and an annular cage which is provided with circumferentially distributed windows, which receives the balls in the windows and holds the balls in one plane, the two constant velocity ratio universal joints being plunging joints in which corresponding first ball tracks and second ball tracks cross one another in developed view of the joint, being inclined in opposite senses relative to the longitudinal axis of the joint, wherein

the inner joint parts are each non-removably connected to the shaft element;

the opening of each cage facing the shaft element has a smallest inner diameter which is smaller than the greatest outer diameter of the respective inner joint part, and the end of the cage facing the shaft element forms an axial stop for the respective inner joint part; and

each inner joint part connected to the shaft element is coaxially introducible into the respective cage by virtue of the cage opening facing the shaft element being enlarged by recesses which comprise a greater radial dimension and a greater circumferential extension than longitudinal webs of the respective inner joint part defined between each two adjacent ball tracks thereof.

4. A propeller shaft according to Claim 3, wherein the recesses are constituted by notches in the cage wall part at the shaft element end of the cage.

5. A propeller shaft according to Claim 3, wherein the recesses are constituted by corrugations in the cage wall part at the shaft element end of the cage, the wall thickness of the wall part remaining unchanged.

6. A propeller shaft according to Claim 5, wherein the corrugations are formed by alternating part-spherical portions of the cage wall part at the shaft element end of the cage and portions expanded relative to said part-spherical portions.

7. A propeller shaft according to any one of Claims 1 to 6, wherein the inner diameter of the opening of the cage, which opening faces away from the shaft element, is smaller than the outer diameter of the inner joint part and forms an axial stop for the inner joint part.

8. A propeller shaft according to any one of Claims 1 to 6, wherein the inner diameter of the opening of the cage, which opening faces away from the shaft element, is greater than the outer diameter of the inner joint part and the outer joint part is provided with a part-spherical axial stop face for the cage.

9. A propeller shaft according to any one of Claims 1 to 6, wherein the inner diameter of the opening of the cage, which faces away from the shaft element is greater than the outer diameter of the inner joint part and the outer joint part is provided with an axial stop face for the inner joint part.

10. A propeller shaft according to any one of Claims 1 to 9, wherein the shaft element is a tubular member.

11. A propeller shaft according to any one of Claims 1 to 10, wherein the shaft element is integral with the inner joint parts.

12. A propeller shaft according to any one of Claims 1 to 10, wherein the shaft element has been welded to the inner joint parts of the plunging joints and has subsequently been subjected to a hardening treatment.

13. A propeller shaft substantially as hereinbefore described with reference to any of the accompanying drawings.